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CURRENT LITERATURE

MINOR NOTICES

North American flora.—The third part of Vol. 10 continues the presentation of the Agaricaceae by MURRILL,[1] the 12 genera of Pholiotanae being presented, excepting the genus *Inocybe*. The 11 genera presented include 324 species, of which 76 are described as new. The largest genera are *Gymnopilus* (85 spp.), *Naucoria* (65 spp.), *Hebeloma* (50 spp.), *Crepidotus* (46 spp.), and *Galerula* (33 spp.). The remaining 45 species are distributed among 6 genera. New species are described in *Crepidotus* (7), *Tubaria* (4), *Galerula* (8), *Naucoria* (21), *Pluteolus* (4), *Mycena* (2), *Gymnopilus* (13), and *Hebeloma* (17).—J. M. C.

NOTES FOR STUDENTS

Carbon assimilation.—JORGENSEN and STILES[2] have summarized our knowledge of the processes involved in the assimilation of carbon by green plants and the pigments concerned in them. The portion dealing with the pigments themselves has been reviewed by LINK.[3] In the introduction the reviewers express the hope that "the following pages will be of interest to those concerned in the development of scientific agriculture as well as to those interested in plant physiology for its own sake." The discussion of the path of gaseous exchange between the leaf and the surrounding atmosphere is based mainly on the work of BLACKMAN and BROWN and ESCOMBE. The conclusion reached is that the proof is now definite that the stomata are the main path of the intake of carbon dioxide into the assimilating aerial leaf of the higher plants. Any intake that may occur through the cuticle is of very minor importance. Carbon assimilation is regarded as a complex of processes which probably obey quite different laws. Attention is called to the 5 obvious factors upon which the rate of carbon assimilation in the leaf may depend: (1) carbon dioxide supply, (2) intensity of illumination, (3) temperature, (4) water supply, (5) quantity of chlorophyll. To these is added BLACKMAN'S time factor. It is found that below 25° C. the rate of carbon assimilation a little more than doubles for each rise of 10° C. For cherry laurel this gives a van't Hoff curve in which the temperature coefficient for a rise of 10° C. is 2.1. In *Helianthus tuberosus* it was 2.5. Below 25° C. the initial rate is maintained, but above that temperature it falls off regularly. The higher the temperature the more rapid is the falling off. The falling off at any given temperature is most rapid at first and subsequently becomes less rapid.

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[1] MURRILL, W. A., North American flora **10**:part 3. pp. 145–226. Agaricales: Agaricaceae (pars), Agariceae (pars). New York Botanical Garden. 1917.

[2] JORGENSEN, I., and STILES, W., Carbon assimilation. A review of recent work on the pigments of the green leaf and the processes connected with them. New Phytol. reprint no. 10. London. Wesley & Son. 1917.

[3] BOT. GAZ. **62**:417–421. 1916.

Since it is thus impossible to measure the highest possible assimilation at high temperatures, BLACKMAN estimates it by plotting his experimental results below 25° C. (a van't Hoff curve in which $Q_{10}=2.1$) and continuing the curve by assuming that the same rule is followed above that temperature. That this curve represents the initial rate above 25° C. is confirmed in BLACKMAN'S opinion by plotting on this same diagram (the abscissae now having a time significance instead of a temperature significance) the values obtained for the assimilation rate at higher temperatures, and continuing these curves back to a point representing zero time. It is thus found that the position representing zero time for each curve is also that representing the temperature at which the readings were taken.

On this basis BLACKMAN concludes that there seems to be reason for the preliminary acceptance of the theory that the initial values of assimilation above 25° C. follow the van't Hoff curve as they do below that temperature. JORGENSEN and STILES seem disposed to defend BLACKMAN against all criticisms on this point. It must be remembered, however, that COHEN-STUART[4] has shown that, according to the van't Hoff law itself, values of Q_{10} are not constants and that the velocity is not an exponential function of the temperature. KUIJPER[5] found that such a method as BLACKMAN used on carbon assimilation did not apply to respiration. LEITSCH[6] has also found that it does not apply to temperature and rate of growth.

In regard to the light factor, the conclusion is reached that "where temperature and carbon dioxide supply are in excess the rate of assimilation is in direct proportion to the intensity of illumination." In the case of cherry laurel during the middle of an August day (temperature 29°5 C.) the maximum assimilation was possible with 36 per cent of full sunlight, while in the case of *Helianthus* 69 per cent was necessary.

Assimilation is shown to increase directly with carbon dioxide supply until some other factor becomes the limiting one. When this point is reached, assimilation remains constant with further increases in carbon dioxide up to 0.0536 per cent. Above this point the rate of assimilation falls off rapidly. BLACKMAN'S interpretation is that this is due to the narcotic effect of the strong CO_2 on the protoplasm. The reviewers state that "BLACKMAN carefully avoids premature conclusions and tries to find non-committal expressions which will embody all his experimental results."

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[4] Konn. Akad. Wetans. Amsterdam. Proc. Sec. Sci. **14**:1159–1172. 1912.

[5] Rev. BOT. GAZ. **50**:233–234. 1910.

[6] Ann. Botany **30**:25–46.

In discussing WILLSTÄTTER'S work on the relation between chlorophyll content and assimilation rate, the reviewers state that "WILLSTÄTTER advances a simple definite hypothesis and attempts to obtain experimental data which will support his theory." WILLSTÄTTER postulates that carbon assimilation consists of two definite processes, one photochemical, taking place in the chloroplast, and one enzymatic, taking place at the boundary between the chloroplast and the plasma. The oxygen is supposedly evolved during the latter process. The experimental proof of this postulate is incomplete. The view is not a surprising one, however, since the relation of carbon assimilation and of enzymatic action to temperature both seem to be special cases of TAMMAN'S principle. The surprising thing would be that there should be only two processes concerned. The reviewers state that under certain circumstances, when no other factor is limiting, the amount of chlorophyll determines the intake of CO_2 by the leaf. WILLSTÄTTER found that the amount of pigment is not altered during the process of carbon assimilation.

The discussion of the present status of our knowledge of the known products of assimilation (oxygen and carbohydrates) is based on the work done within the last 31 years, since the earlier workers did not separate the gaseous exchanges due to assimilation from those due to respiration. It seems probable that the real assimilation coefficient (taking respiration into account) approximates unity. In considering the nature of a reaction or a series of reactions, it is very important to know the quantitative relation between initial substances and the final products of the reaction. In carbon assimilation by green leaves the relation between CO_2 taken in and O_2 evolved has not been definitely established.

The reviewers summarize in a table (p. 106) the evidence in regard to the presence of various carbohydrates in the leaf. (1) *Polysaccharides* (exclusive of cellulose and pectic substances); the presence of starch has of course long been well known, and the presence of pentosans and dextrin seems to be established. (2) *Disaccharides;* sucrose is certain, and maltose is doubtful. (3) *Hexoses;* the presence of d-glucose and d-fructose is well recognized. (4) *Pentoses;* none are positively known to be present, although there is some evidence pointing to the presence of l-arabinose and l-xylose. Definite evidence as to what sugars are absent and more quantitative data in regard to the ones present are much to be desired. The reviewers state that there is strong evidence that sugars are the first definitely known products of the assimilatory process, starch probably being a secondary product. Although most workers regard cane sugar as first, there is no satisfactory evidence that the hexoses may not be first. The mechanism of translocation is complex, depending upon differences of enzyme concentration, and possibly upon permeability changes, the nature and causes of which are at present largely unknown. The available data on energy relations are dealt with under three heads: (1) quantitative determinations of materials produced and their heats of combustion, (2) measurement of both radiant energy and heats of combustion, (3) assimilation power of light of different wave lengths. Under (1) two methods of estimating the products of carbon are discussed: (*a*) increase in dry weight, and (*b*) amount of CO_2 taken in. The reviewers conclude that if the dry weight method can be made more accurate, it should not be lightly abandoned. If we assume with BROWN and ESCOMBE that the heat of combustion of all products of assimilation is the same as that of glucose (3.76×10^3 gram calories), we shall fall into a considerable error, as is indicated by the following values for other substances present in leaves: sucrose 3.99×10^3, starch 4.1×10^3, cellulose 4.2×10^3. If oils are present, the error in this assumption would be still greater. Actual determinations of heat of combustion made by other workers on the products of assimilation in the leaves of various plants give values varying from 4.4×10^3 to 5.2×10^3 gram calories.

Quantitative measurements of radiant energy in relation to the leaf are based on the assumption that the total radiant energy falling upon the leaf is disposed of in the following ways: (1) reflection from the leaf surface, (2) carbon assimilation, (3) transpiration, (4) transmission through the leaf, (5) thermal emission.

BROWN and ESCOMBE (1905) disregard (1) in their calculations. The reviewers believe that this is not negligible, since even a black cloth may reflect 1 per cent of the radiant energy incident upon it. PURIEWITSCH (1914) has estimated (2) in a few cases by measurement of the increased heat of combustion of the leaf per unit area. His highest value was 2.6 and his lowest 1.3 per cent. On the basis of these he calculated other cases, getting as high as 7.7 per cent. BROWN and ESCOMBE calculated (2) by assuming that one gram of absorbed CO_2 is equivalent to 0.64 gram of dry matter formed, and that the heat of combustion of the products of assimilation is 3.76×10^3 gram calories. The accuracy of these assumptions is not confirmed by measurements. Their computed values vary from 0.42 to 1.66 per cent. All of the evidence at hand thus indicates that only a very small percentage of the radiant energy received by the leaf is actually used in carbon assimilation. It might be expected that the proportion of the sun's energy used in assimilation would vary inversely as the intensity of the illumination. This expectation is not justified by the experimental data, and it is clear that we must look for some other factor on which no data are given. The reviewers point out here a case of lack of correlation of effort by investigators. If PURIEWITSCH had taken cognizance of BLACKMAN'S researches, his experiments (although regarded by PURIEWITSCH himself as preliminary) might have yielded results of much greater significance. The energy used in (3) was arrived at by BROWN and ESCOMBE by determining by weight the amount of transpiration and calculating the energy used from the heat of the vaporization of water at that particular temperature. Their results vary from 9.67 to 53.6 per cent. BROWN and ESCOMBE measured (4) directly. Their values quoted by the reviewers vary but little, the highest being 35.32 and the lowest 35.28 per cent. It is evident that (5) will usually have a positive value, since the temperature of the leaf is usually higher than that of the air. If, however, the temperature of the leaf falls lower than that of the air, the leaf will gain energy from the air, that is, thermal emission will be negative. BROWN and ESCOMBE's values for thermal emission are based on the same set of experiments as the data quoted under (2), (3), and (4). They are all positive. The smallest one is 6.0 and the largest is 54.60 per cent. BROWN and ESCOMBE were the first to attempt to obtain a complete balance sheet for the leaf in regard to energy. Further quantitative data correlating the work of BLACKMAN, BROWN and ESCOMBE, and PURIEWITSCH are greatly to be desired. We still have no reliable data on which any conclusion can be based as to the relative efficiency of the rays in the different portions of the spectrum.

The reviewers mention the early work, indicating that the maximum assimilation takes place in the red part of the spectrum and that there is a secondary maximum in the blue-violet end as being now of only historical interest, since the methods of measuring energy were unsatisfactory and the measurements of assimilation were crude.

The work of KNIEP and MINDER (1909), indicating that blue and red light of the same intensity produce the same assimilation and that the green light is incapable of producing assimilation, is rejected because they give no data relating to any factors other than light intensity, hence some other factor may have been a limiting one. They also reject TIMIARIZEFF's (1903) data on the absorption of energy by chlorophyll, since he worked with alcoholic extracts, which must have contained less chlorophyll than impurities. The work of BROWN and ESCOMBE on the absorption of radiant energy by the white and the green portion of a leaf of *Negundo aceroides* is also rejected, since it is considered unfair to assume that the conditions in the green and the albino parts are the same except for the presence of chlorophyll. WEIGERT's (1911) conclusions on the efficiency of the assimilation system are considered unreliable, since they are based on the work of BROWN and ESCOMBE just mentioned.

The reviewers introduce their discussion of theories of carbon assimilation with a sweeping condemnation of theories, making the point that those who have contributed the most valuable data on this subject have not suggested any theories. They cite DE SAUSSURE, SACHS, PFEFFER, and BLACKMAN as examples. They might possibly have added SPOEHR to the list, but they could not have added WILLSTÄTTER, since his data on the pigments of the green leaf are certainly very valuable, and considerable space is given in their review to the discussion of his theories.

Of course blind following of a theory does not lead to progress, and the desirable attitude is that of seeking for facts regardless of their bearing on any theory, but to assume that none of the workers (except SPOEHR) have been influenced by dissatisfaction with the theories that have been advanced seems unwarranted. It is not the right use of scientific imagination that is to be condemned, but the acceptance of mere imaginings as facts. JORGENSEN and STILES, of course, are quite right in their condemnation of whatever tendency there may have been in textbooks to present BAYER'S hypothesis as representing facts.

They discuss the theories and suggestions of four men: (1) the well known theory of BAYER involving formaldehyde as an intermediate product; (2) the suggestion of VAN'T HOFF that assimilation consists of two parts, a photochemical reaction and an enzyme reaction; (3) SIEGFRIED'S suggestion that carbon dioxide may form carbamino groups with the protoplasm of the plant cell and that the photochemical reaction may then occur in a complex carbon compound; and (4) WILLSTÄTTER'S theories which, so far as they are new, are regarded by the reviewers as rather wild, the most reasonable one suggested by him being merely a repetition of SIEGFRIED'S suggestion.

In the end it appears that we have at present no satisfactory theory of the changes that take place between the entrance of CO_2 into the plant and the production of carbohydrates.

Although deploring the lack of coordination among the various workers, and the tendency of botanists to accept without question the suggestions of physicists and chemists as to the nature of plant processes, the reviewers conclude that plant physiology is developing into an exact science, utilizing the experiences of the fundamental sciences, physics and chemistry, but having working principles and methods of its own. That it will thus be of great service in plant production requires no prophetic vision.—GEORGE B. RIGG.

Studies on oxidases.—In connection with his work on plant oxidases, BUNZELL[7] has published results of an investigation of the effect of hydrogen-ion concentration, C_h, on oxidase activity. Using his own simplified oxidase apparatus to measure oxidation and the gas chain to measure hydrogen-ion concentration, he finds that the oxidase activity of several kinds of material from potato tubers is completely inhibited by a C_h of $2.0–2.8 \times 10^{-4}$. The various concentrations were obtained by adding sodium hydroxide and acetic acid in various proportions, or either one alone, to mixtures of the plant material and pyrocatechin.

It is worth noting here that the two together constitute a true buffer solution capable of maintaining a fairly constant hydrogen-ion concentration, but that neither one alone suffices. Consequently, if there is a tendency for the acidity to increase in the Bunzell apparatus, as suggested by ROSE[8] in 1915, conditions are not comparable in the different mixtures. Those containing the true buffer solution will have practically a constant C_h throughout the course of the experiment, while those containing only sodium hydroxide or acetic acid will have a C_h which is larger at the end than at the beginning. The

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[7] BUNZELL, H. H., The relationship existing between the oxidase activity of plant juices and their hydrogen-ion concentration, with a note on the cause of oxidase activity in plant tissue. Jour. Biol. Chem. **28**:315–333. 1916.

[8] ROSE, D. H., Oxidation in healthy and diseased apple bark. BOT. GAZ. **60**: 55–65. 1915.